Statistical Properties of indices of competitive balance

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Competitive Balance

- Competitive balance is a central concept in the economic analysis of professional sports leagues.
- It refers to the degree of equality of the playing strengths of teams.
- There is considerable interest in studying competitive balance across time since it affects
  - the attendance demand and profits as well as fans welfare;
  - the uncertainty of outcome in sport leagues.

Indices of competitive balance

- Various measures of competitive balance have been used in the literature
- Typically they measure
  - competition within season
  - competition across seasons
- There is a great variety of indices aiming to capture several characteristics of competitions, different sports, measuring effect of interventions etc

Indices

Competitive balance refers to the uncertainty of the sports competition. The result is not known a priori and this makes sports very challenging BUT

- Uncertainty is present not only within each match but also within each season.
- the final standings record this uncertainty.
- Indices do not account for this stochasticity since
  - They are used as single indices without the necessary variability attached to them.
  - They are normalized with respect an improbable and unrealistic scenario of not only equal strength but also also equal result and rankings at the final standings.

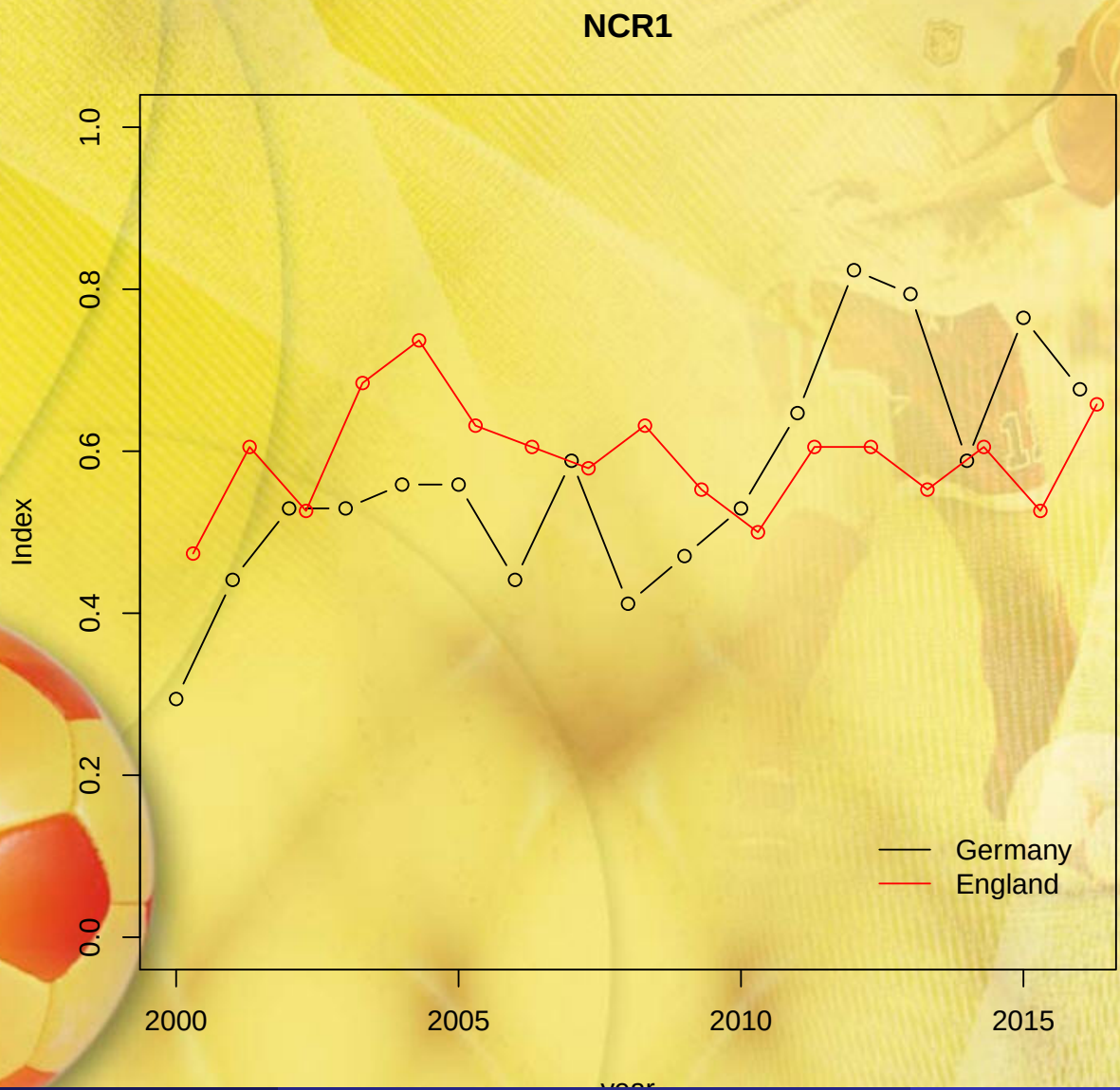
In this work, we account for this uncertainty and setup the baseline of a more realistic stochastic scenario of equal strength.

Motivate the study

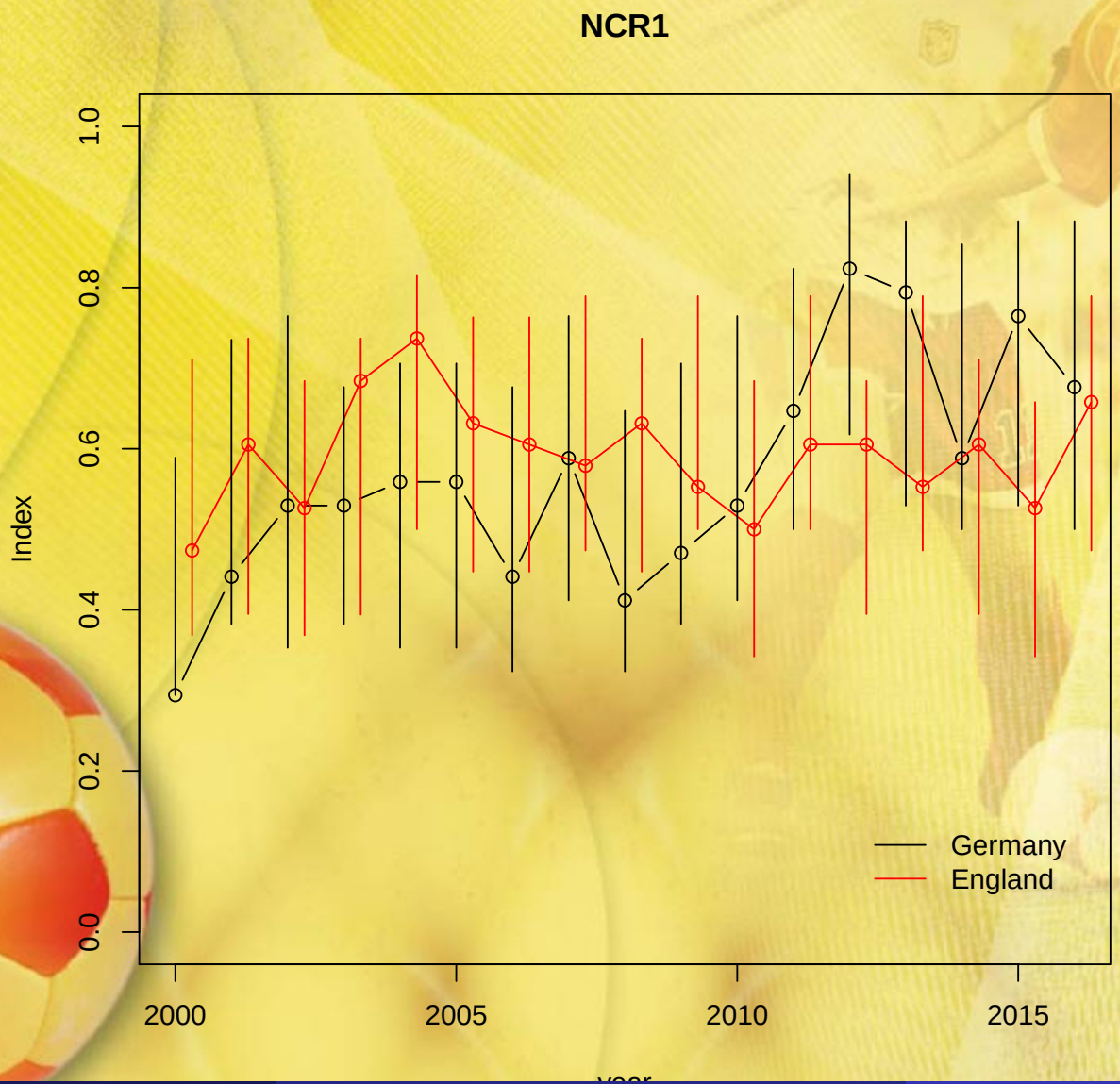
To motivate the present work we consider the following:

- Data from Premier League and Bundesliga
- Seasons: from 2000-2001 up to 2016-2017
- We use two indices.
  - Normalized Concentration Ratio: an index measuring the competition for the first place (NCR_1)
  - The Herfindahl-Hirschman index (HHI) adjusted for use in competitive balance
- We want to compare the behaviour across time and between the different championships

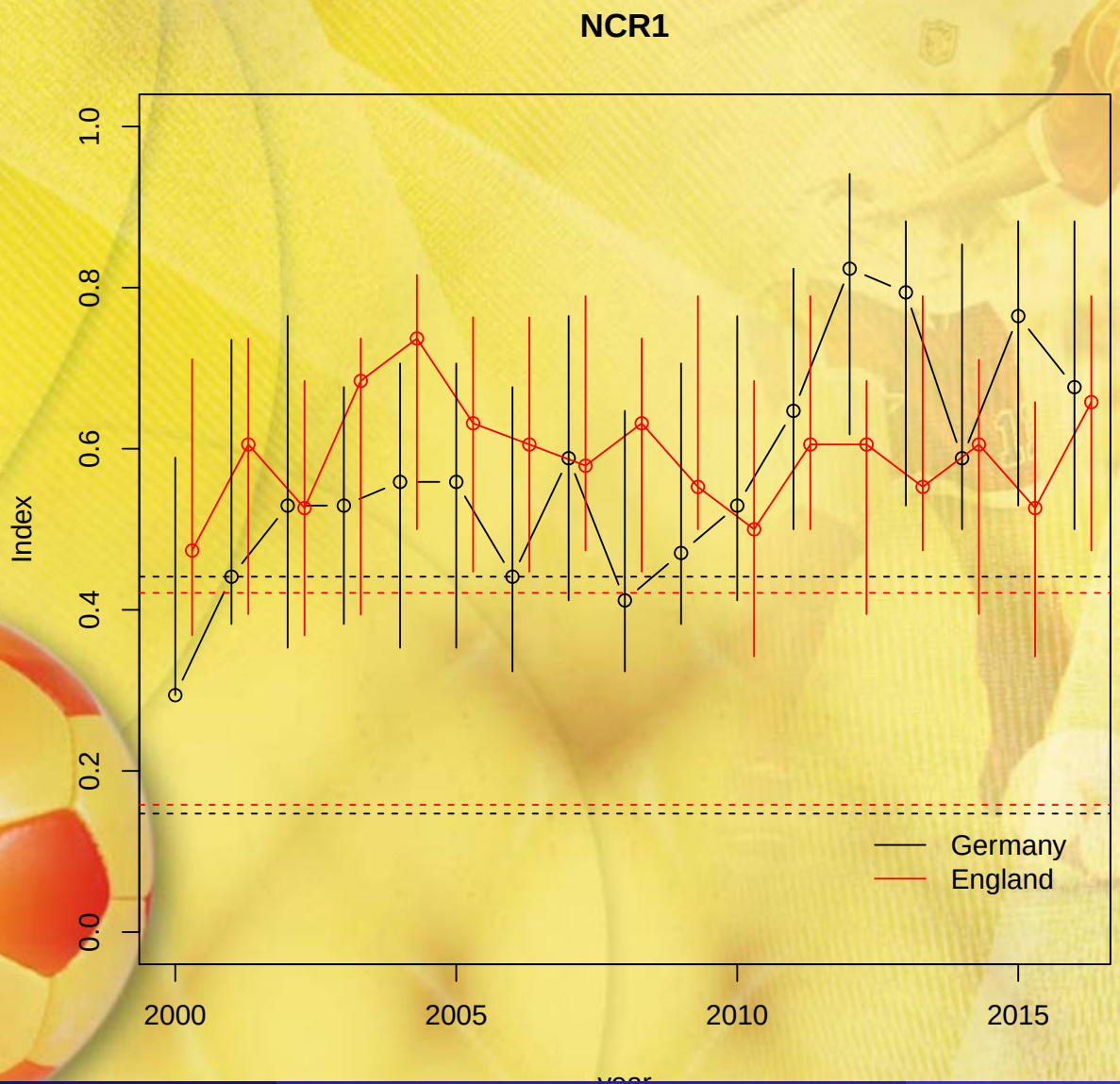
Normalized Concentration Ratio NCR1



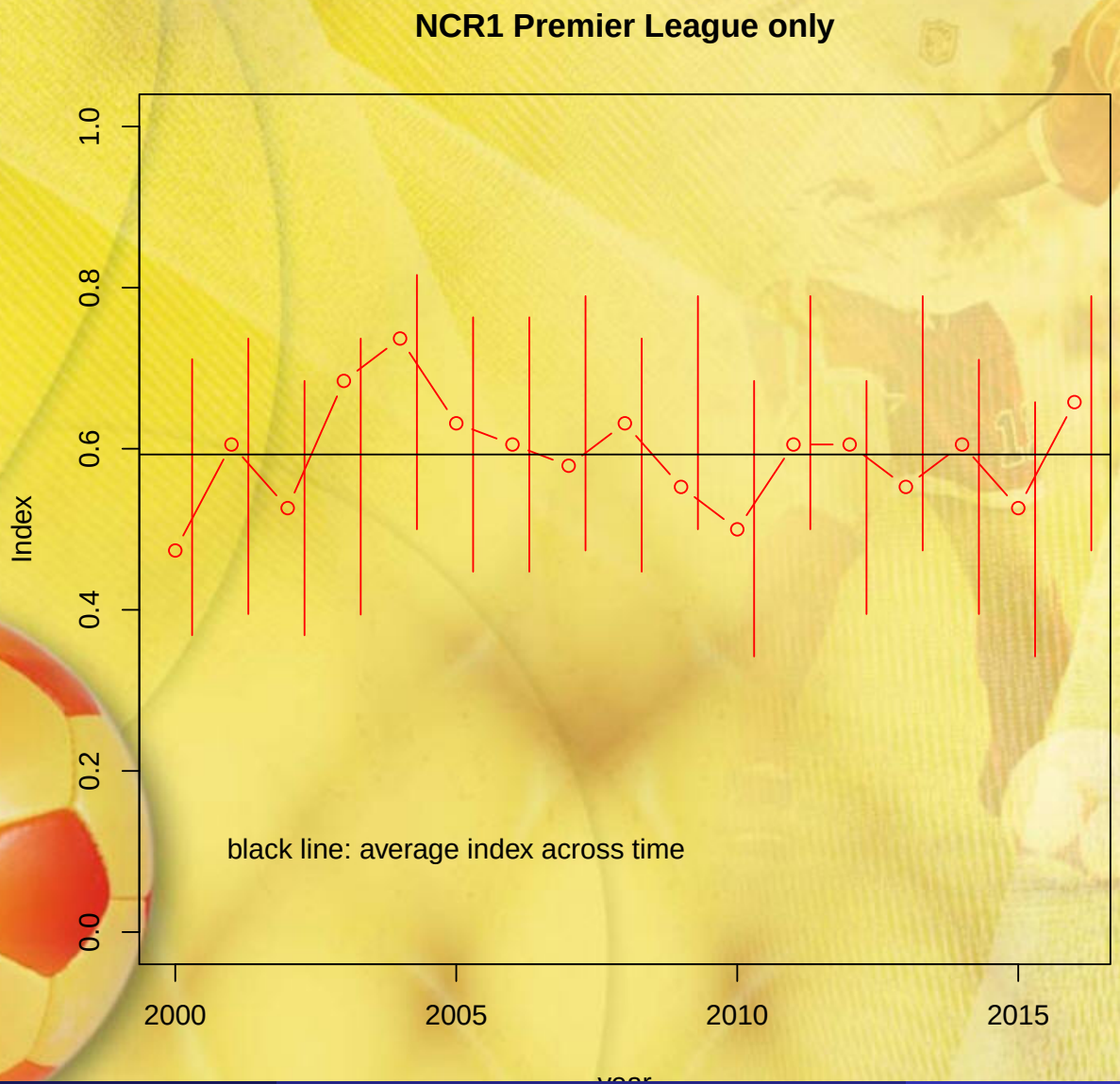
NCR1- Add some CIs



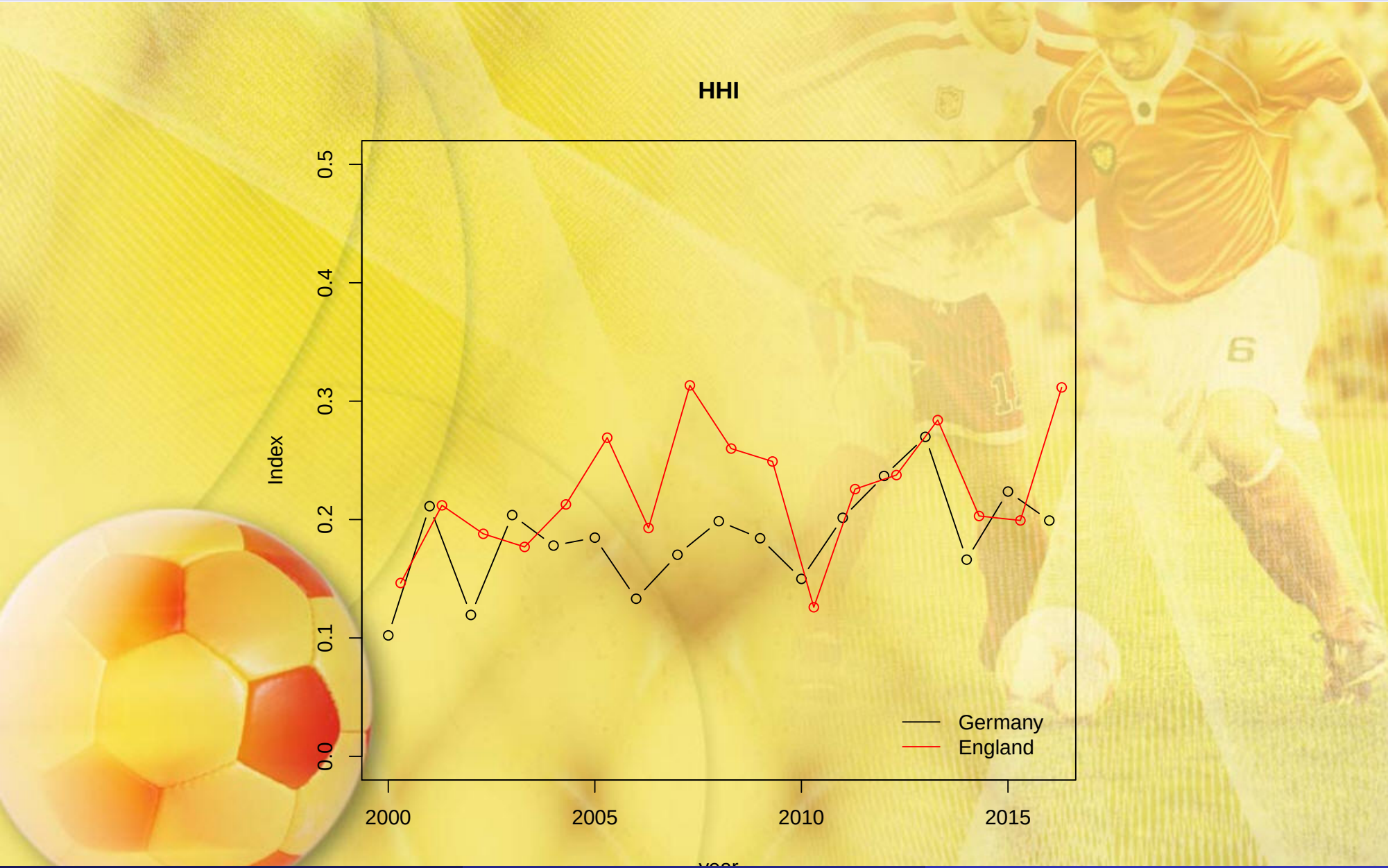
NCR1- What if all teams of equal strength



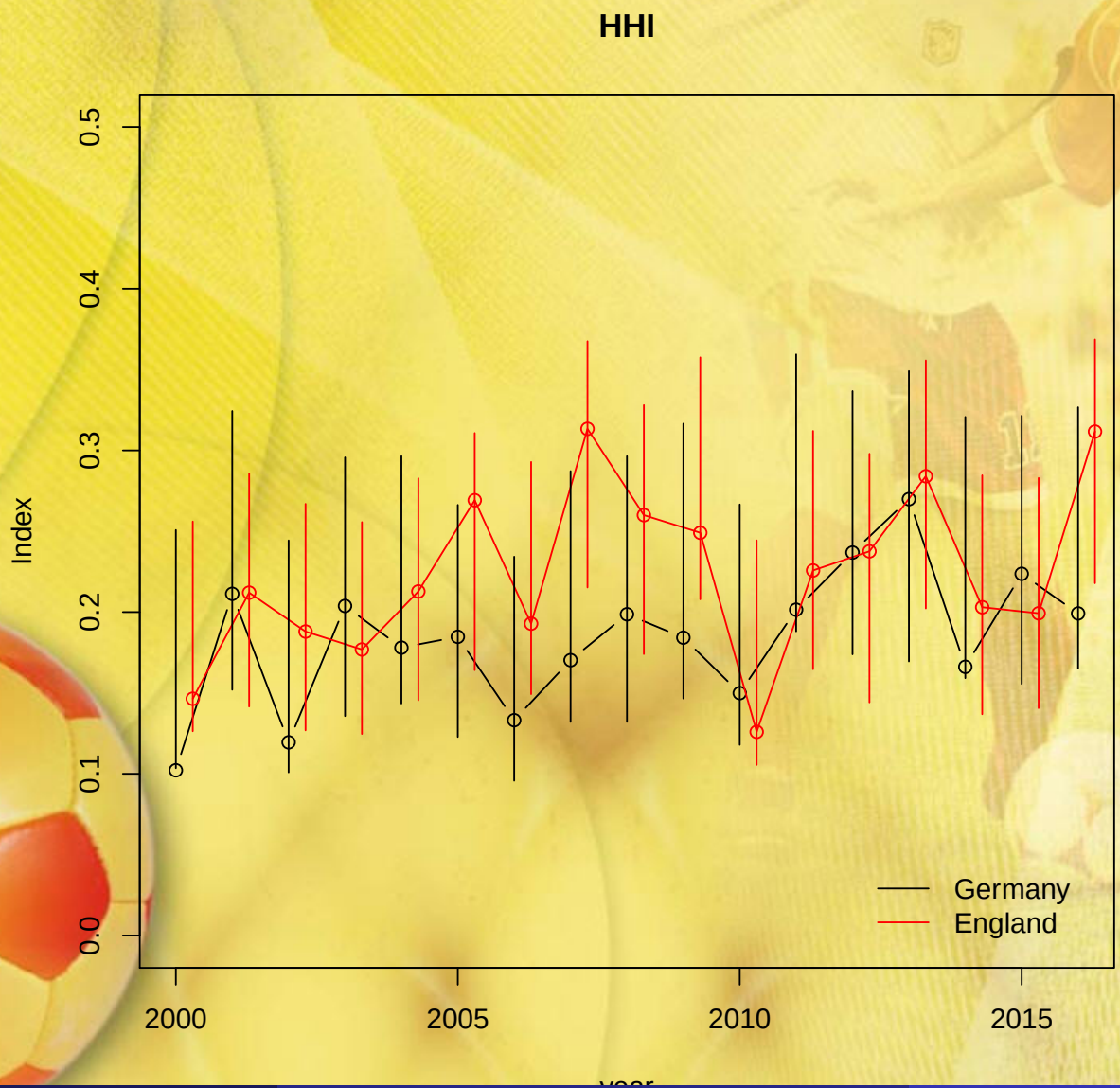
NCR1- Premier League



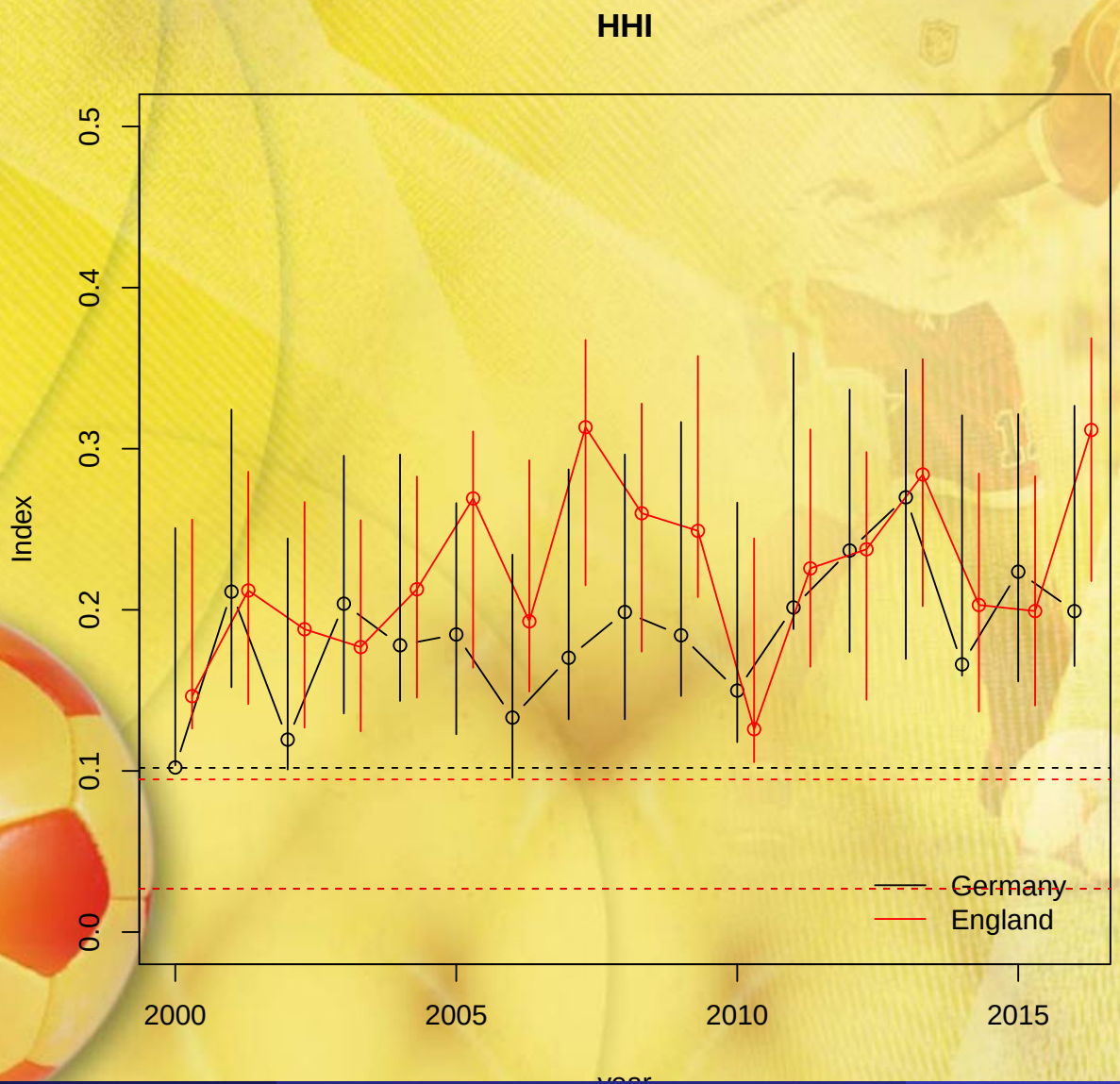
Herfindahl-Hirschman index (HHI)



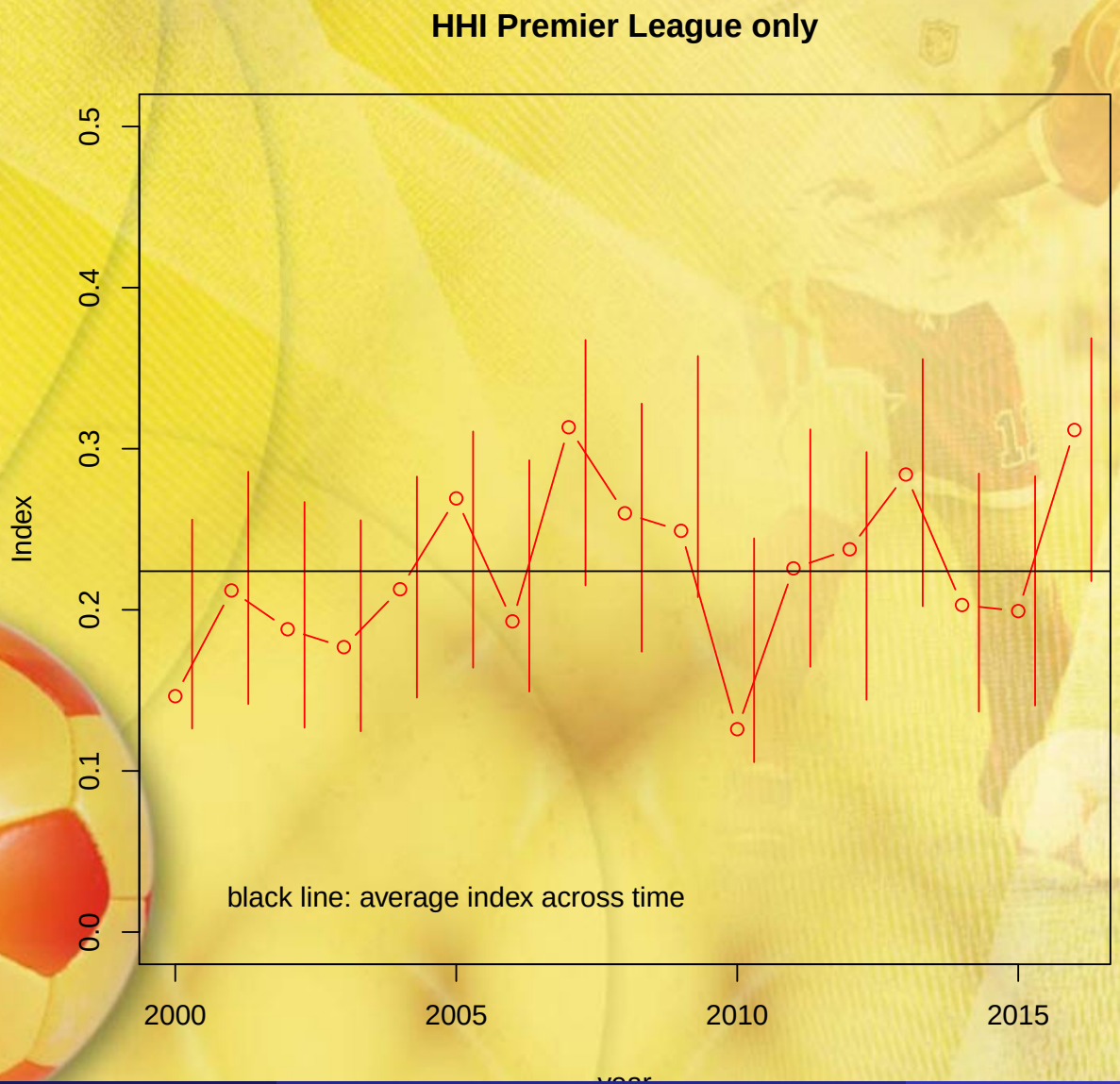
HHI- Add some CIs



HHI- What if all teams of equal strength



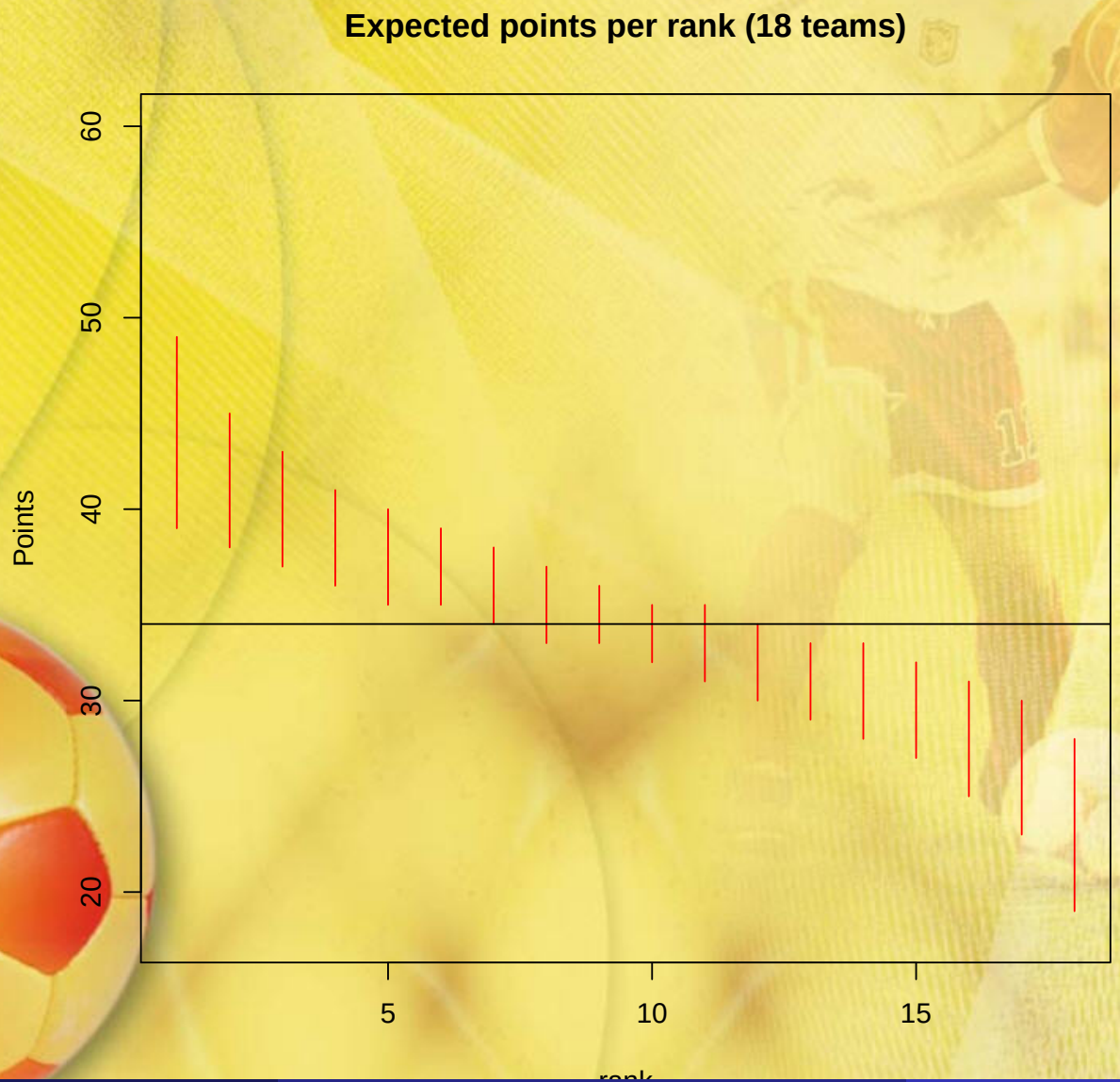
HHI- Premier League



Expected indices under equal strength assumption

- Most indices compare their values with the value expected under equal strength assumption: all teams are of equal strength and all results are drawed with probability one (no uncertainty).
- But is this a totally unrealistic assumption: How many leagues with equal ranks for all teams do you know?
- And even if such a league existed, why this makes the league more interesting since the result of all games will be known a-priori?
- Due to randomness it is improbable to observe a totally balanced final standings table even if all teams are of similar strength!
- So, the idea here is that we need to consider a more realistic scenario for reference for the assumption of a perfectly balanced league.

Expected Points per rank



Story so far

- I need to explain how the CI's are built...
- Lessons that we have (hopefully) learned by now
  - We SHOULD account for variability.
  - European leagues may not be so far away from well balanced leagues.
  - What about home effect under the assumption of a balanced league?

In this work

- We create confidence intervals based on a parametric bootstrap approach.
- We will also discuss (if time permits) about sensitivity
  - on certain assumptions
  - different scenarios
  - different indices
- Our approach is model based in the sense that we replicate the leagues based on the estimated model from the true data.

Existing Related work

- Simulations on Brizzi (2002), Owen and King (2013,2015) for particular indices.
- Some results on some indices but in a very different context.
- Results from other disciplines do not necessarily apply here for many reasons (e.g. Gini coefficient).

Model used

For ith game with home team HT_i against AT_i we have that the number of goals scored follow a Poisson distribution with expected counts λ_{1i} and λ_{2i} respectively.
We use the following Model Structure:

$$\begin{aligned} \log \lambda_{1i} &= \mu + home + att_{HT_i} + def_{AT_i} \\ \log \lambda_{2i} &= \mu + \qquad\quad att_{AT_i} + def_{HT_i} \end{aligned}$$

We have also used

- Negative binomial distribution with the same model structure to check about model deviations.
- Poisson model with different home effect for each team (interaction between home effect and home team).

Resampling approach

We use a parametric bootstrap resampling approach.
The methodology can be summarized by the following steps:

S1: Estimate the model using the data at hand.

S2: Using the model estimated, generate new data (we need to generate the responses, i.e. the number of goals per team, per game under the hypothesized model.

S3: For each generated league, we calculate the indices under study.

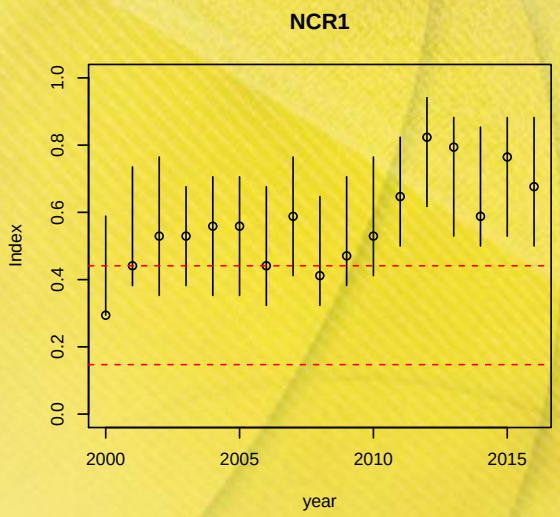
S4: Repeat steps 2 and 3 a number of time, say B. We consider $B = 1000$ leagues.

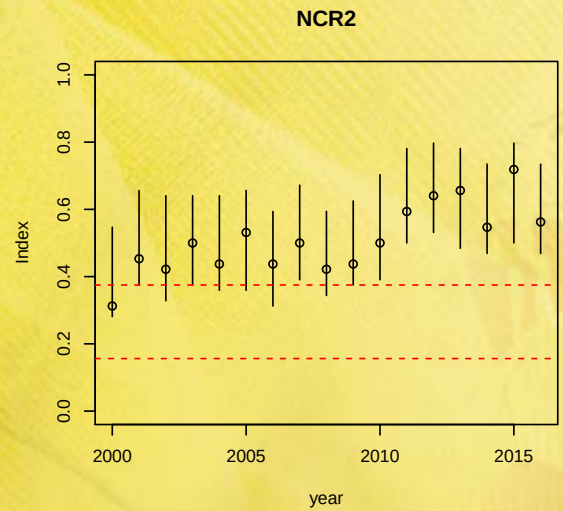
S5: Create confidence intervals using the empirical percentiles of the generated values of the indices. We use 95% confidence intervals.

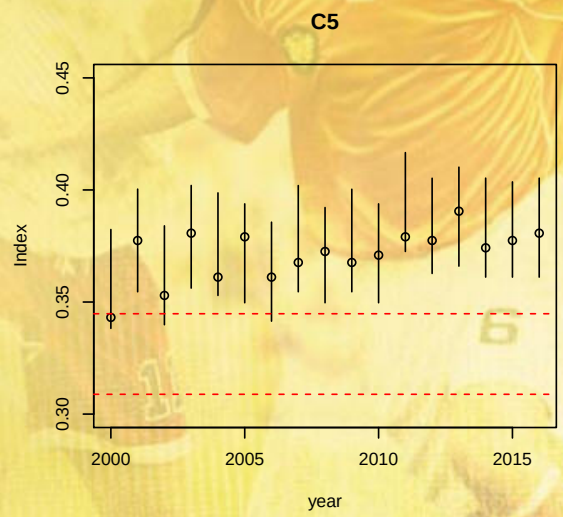
Indices used

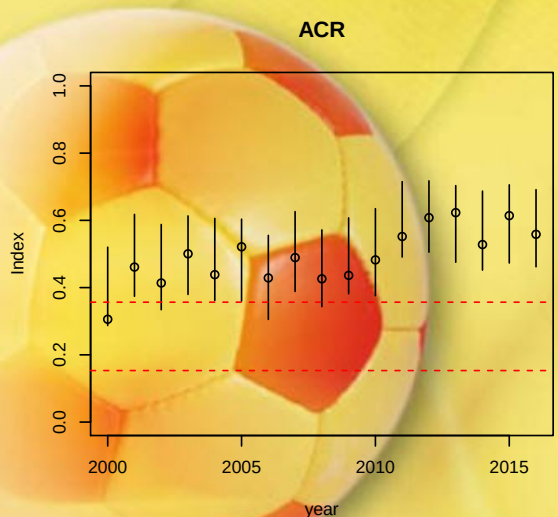
- Normalized Concentration Ratio (NCR) for the 1st place (NCR_1).
- Normalized Concentration Ratio for the 2nd place (NCR_2).
- Average Concentration Ratio (ACR): it is the average for different NCRs.
- C_5: measures the winning percentage of the first 5 teams.
- NCRI considers the competition for relegation.
- The SCR synthesizes competition for relegation with that for the first 5 places.
- The normalized version of the Herfindahl-Hirschman index that measure the share of the teams.
- Relative entropy.
- Gini concentartion coefficient.
- National Measure of Seasonal imbalance (NAMSI) that measures the spread in the winning percentages normalized adequately.

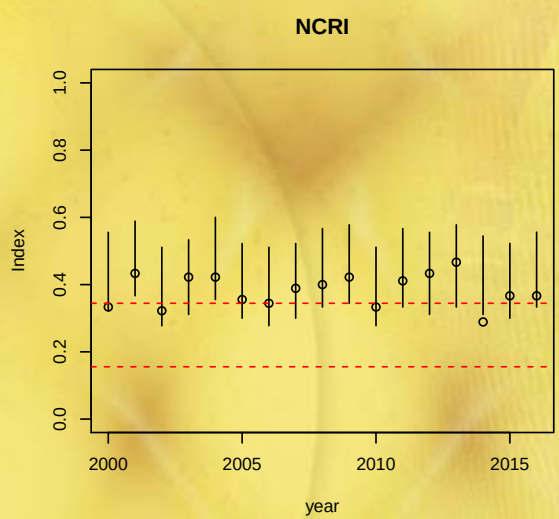
Results for English Premier League

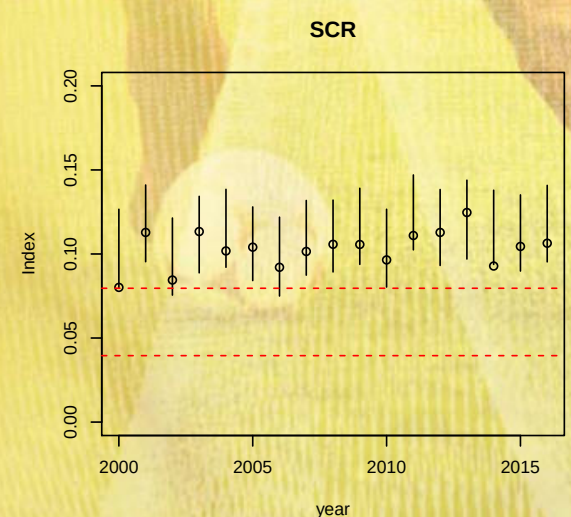












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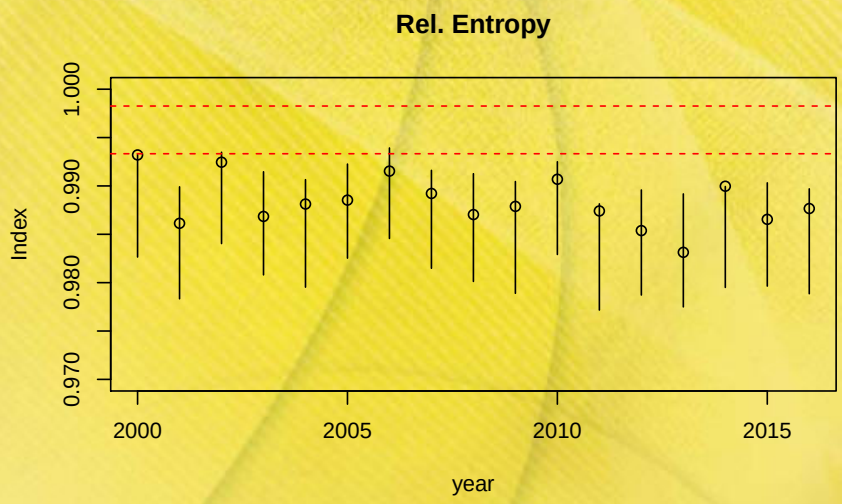
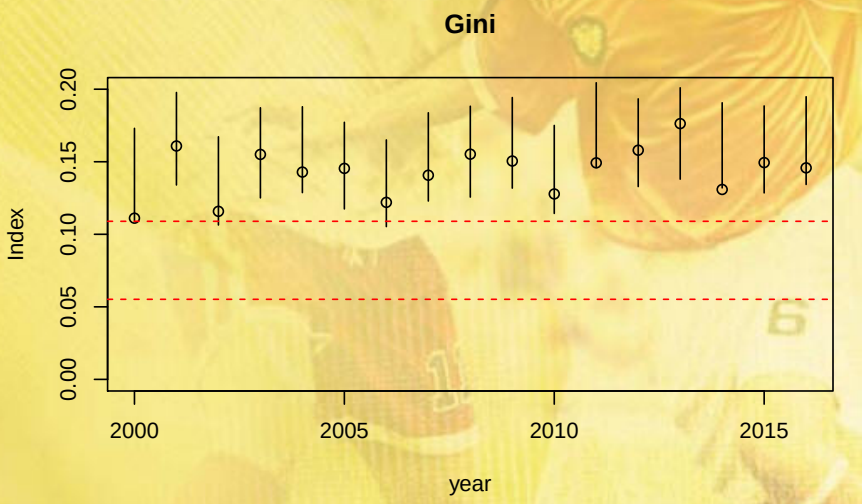
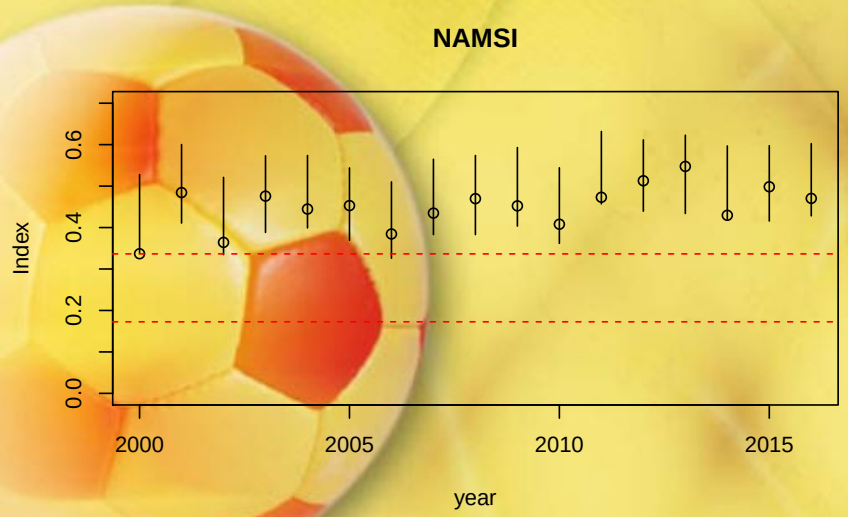
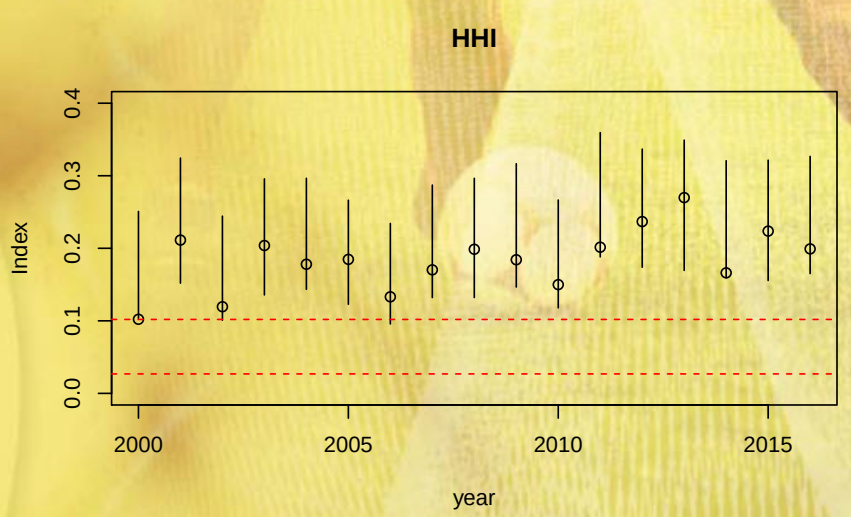
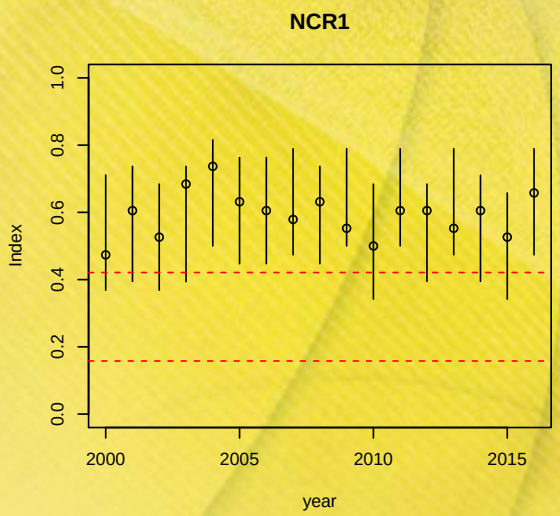


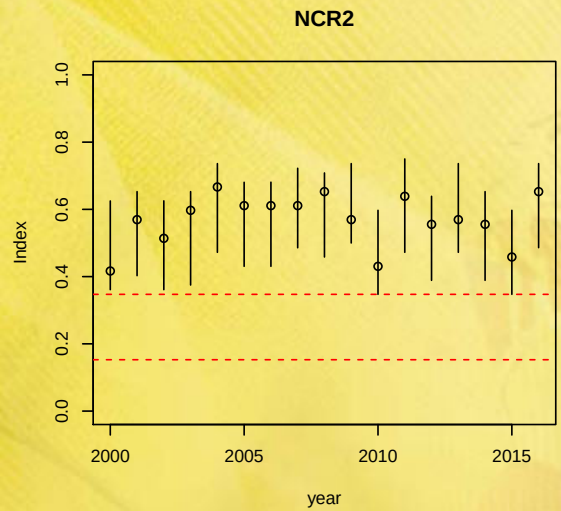


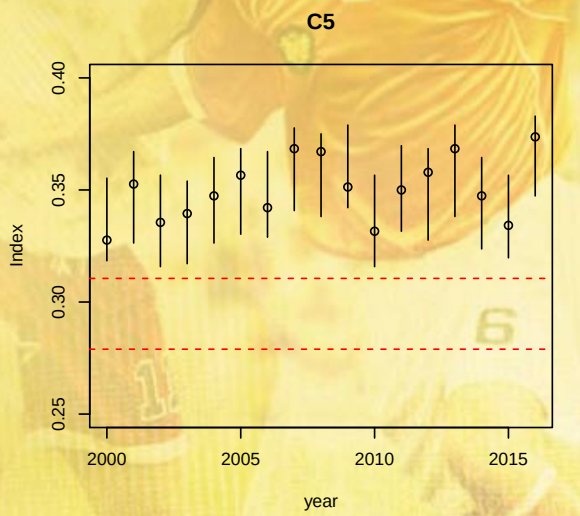


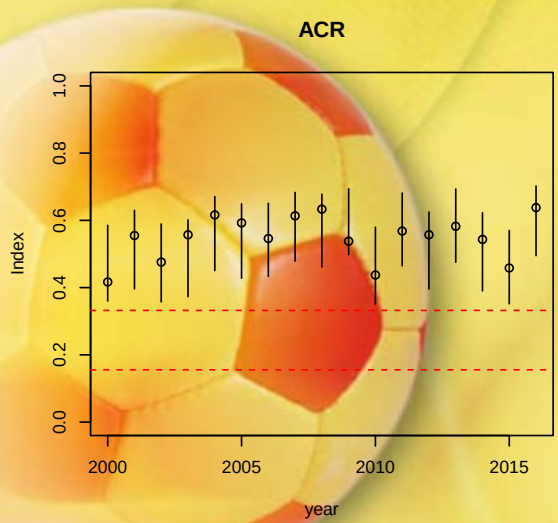


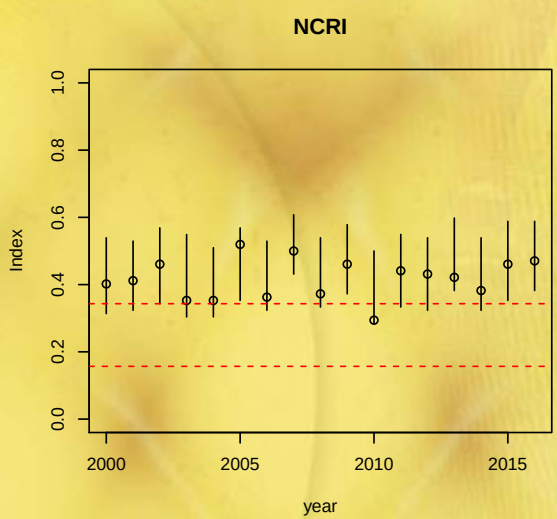
Results for Bundesliga

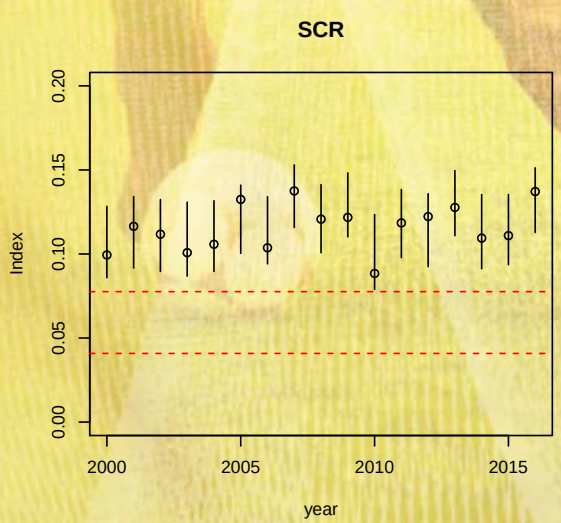












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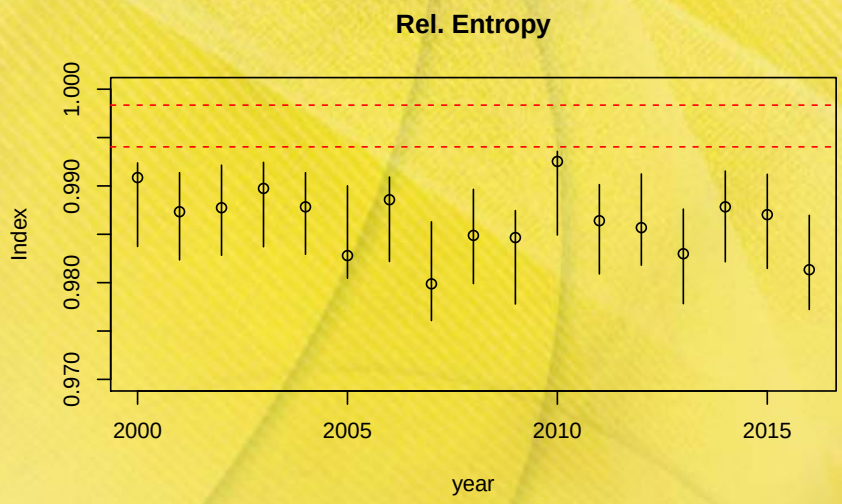
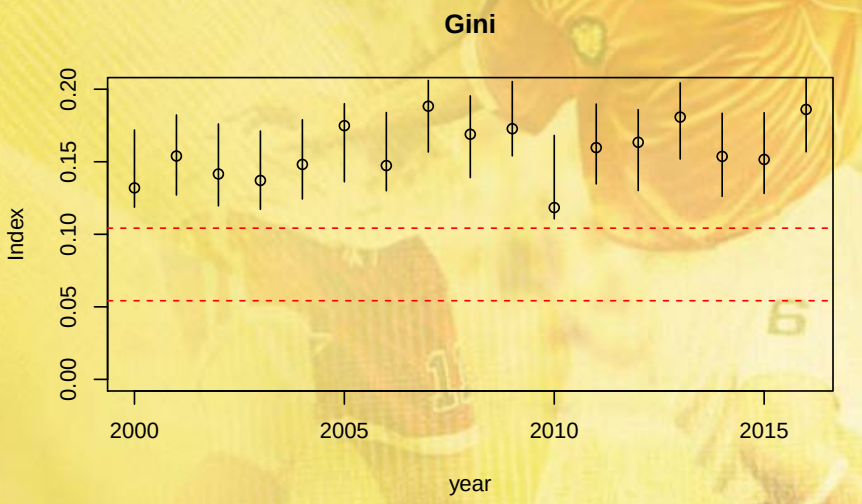
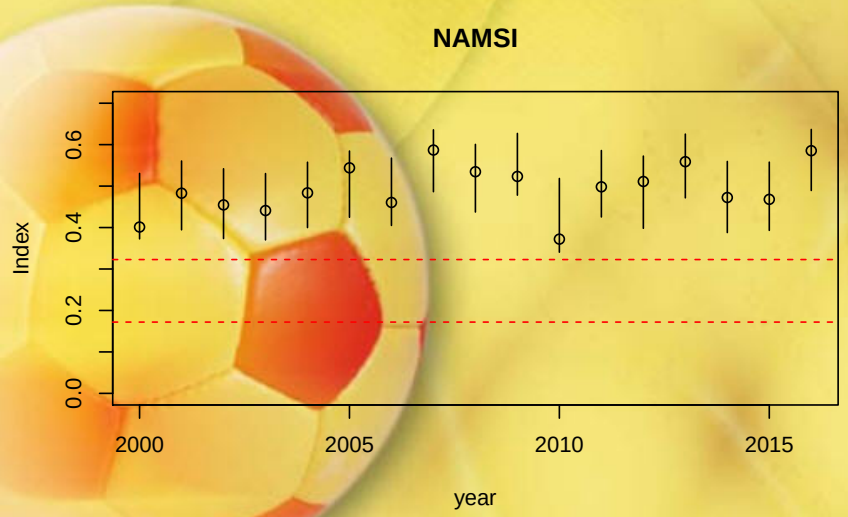
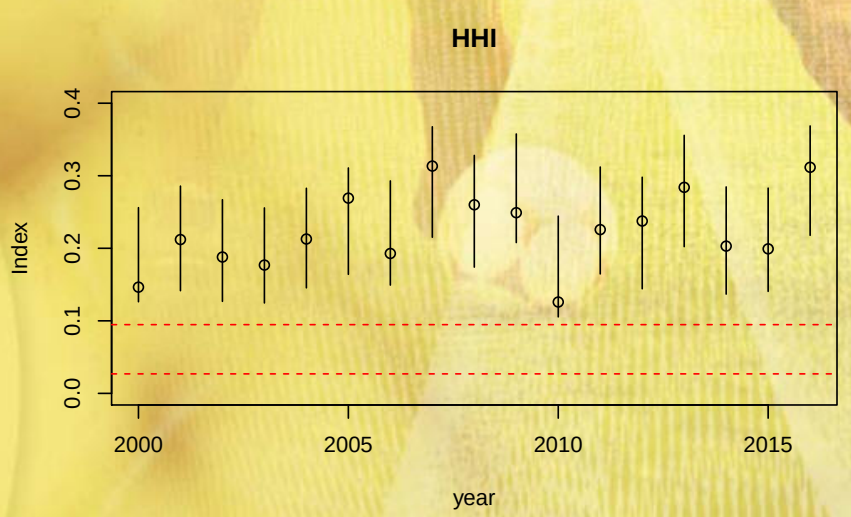






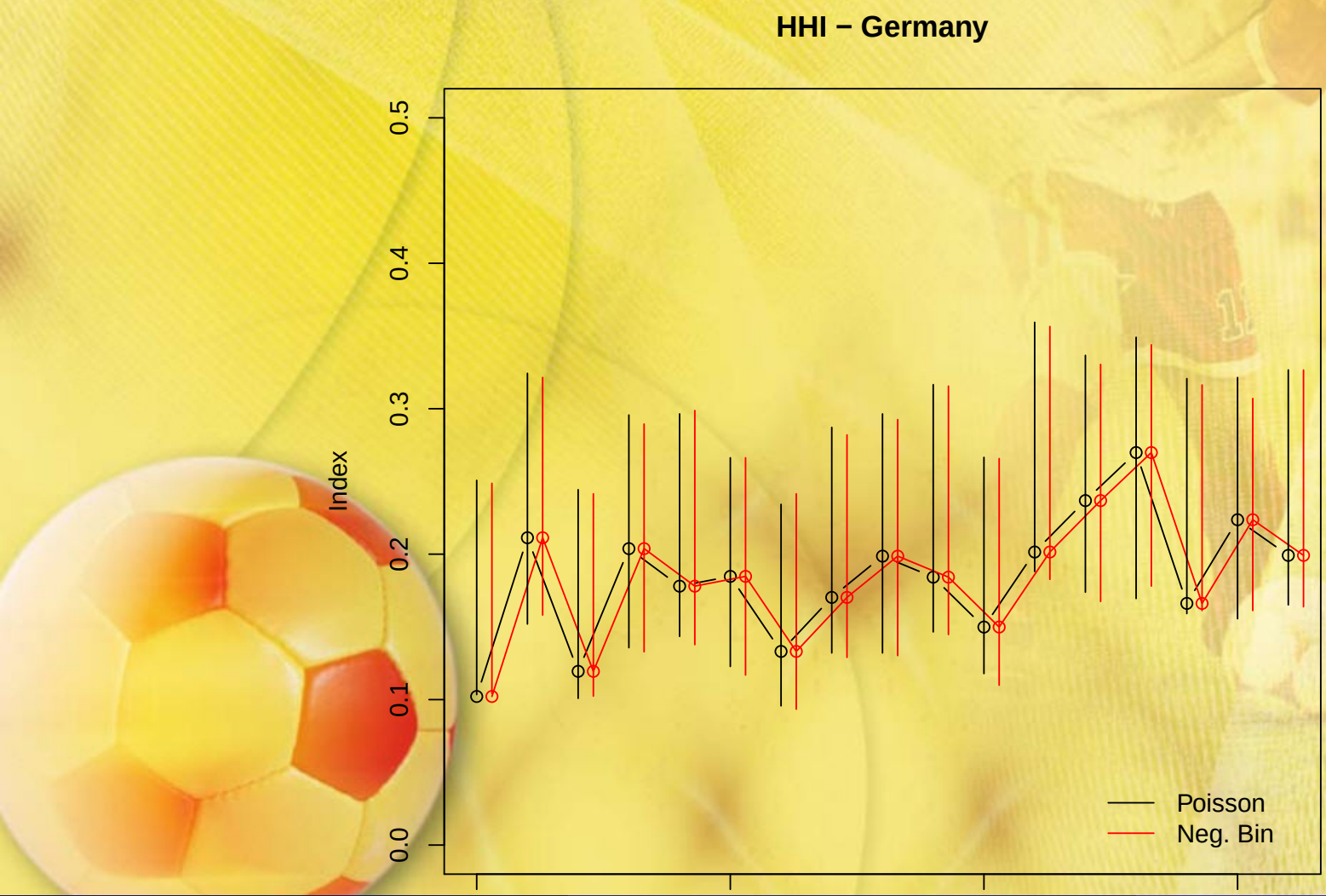


Some Comments- Findings

- The variability depends on the size of the league (number of teams).
- For some indices, variability is large and it seems that the observed values could have been generated by a fully balanced championship.
- Bundelsiga provides indices with clearer separation from the fully balanced scenario
- Taking into account the variability for all indices it changes the picture!
- Can we combine results from different in a single statement about competitiveness?

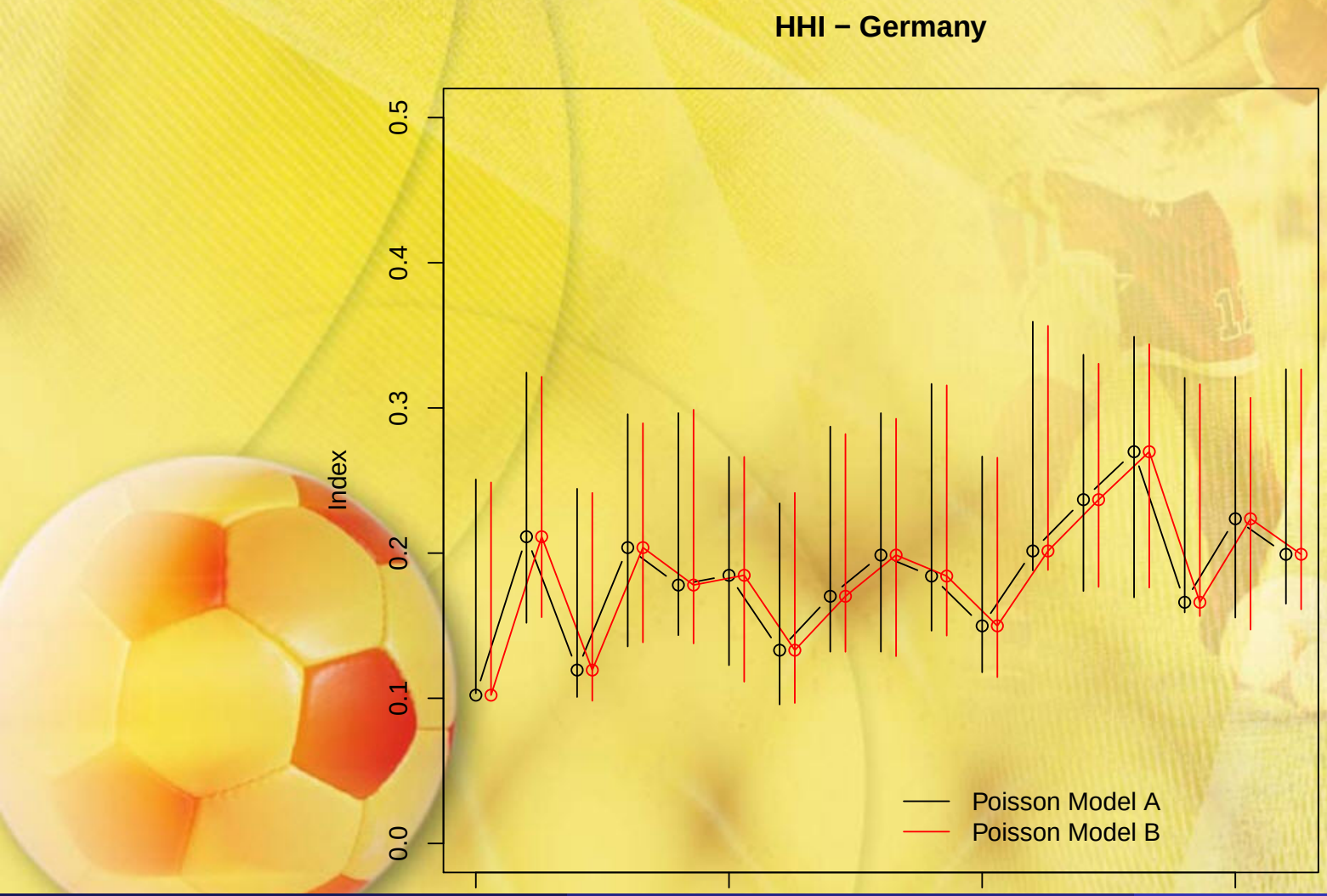
Robustness with respect the model- A

Compare Poisson model with Negative binomial Model



Robustness with respect the model- B

Compare the model with that of varying home effect (Poisson only)



Summarizing

- Competitive balance indices are random variables and we need to account for their stochastic nature.
- Reporting plain numbers does not give the entire picture.
- We proposed confidence intervals based on parametric resampling.
- The approach seems to be robust on model assumptions.

While we focused on within season indices for football, the proposed method can be extended to other indices or sports and to indices measuring balance across seasons.

Further Work

- Current indices make use of the final standing only.
- This makes use of rather limited information about the nature of the balance during the season.
- A natural extension is to consider indices that make use of the scores, the goal difference and/or the standings during the season (not only the final league standings).
- This is work in progress.

Selected bibliography

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Thanks for your attention

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